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ABSTRACT

The paper describes current problems in the design and application of high technology aids for disabled people and offers strategies for addressing those problems. Following an explanation of terms and a description of the functions of an aid system, the following five components of such systems are examined: physical interface, selection technique, acceleration techniques, output forms, and underlying processes involved. Four commercially available aids are analyzed in terms of communication, telephone use, and written display. Issues of control and computer access are also addressed. (CL)

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THE STATE OF THE ART OF HIGH TECH AIDS

MARY E. BRADY

ABSTRACT

This paper describes current problems in high technology aid design and application, and currently available, practical strategies to address these problems. It also raises questions to help you find possible solutions. The Author's goal is to "de-bunk" some of the "hype" of technology without lessening the hope offered by high-technology aids.

When Barry Rodgers and I discussed doing this presentation several months ago, we tried to think of a topic that would be timely and worthwhile to you, and would draw from our work at the Trace Center in a way that would convey the direction of our research and development projects rather than just a description of current activities. We got to talking about the needs of the field, and the role that a federally-funded center plays in meeting those needs. Therefore, I will be talking about the current state of the art in applying technology to communication.

I will be describing what I see as some of the current problems in high technology aid design and application, and some currently available, practical strategies to address these problems. I will also be raising questions and challenging you to help come up with some possible solutions. What I will be talking about is far from ideal yet it represents great progress and some tantalizing opportunities. My goal is to de-bunk some of the hype in this area without deflating any of the hope offered by high-technology aids.

My intention in the first part of this presentation is to detail some of the rather well-known but seldom discussed features of various electronic communication aids. I will spend a fair amount of time first, defining the terms I'll be using, because I feel that one of the biggest problems we have in communicating about the whole area of communication aids, computer access and interface devices is a lack of semantic agreement. So if you will bear with me, I will be defining each of the terms I intend to use, and if you hear me using a term that you're unclear about, let me know

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and I will attempt to define it for the purposes of our discussion.

Now for the disclaimer. Much of what I will be presenting in my section of the talk does not necessarily reflect anyone's opinions but my own. How intelligible is a certain synthesizer? How easy is it to read an LCD display? These opinions are subjective, to say the least. Little if any empirical research exists to guide us in decisions relating to many of these subjective judgments. I feel a need to state this even though it would seem obvious. In our rush to obtain reliable advice and information in this area we often overlook the necessarily subjective nature of this information.

In a very recent discussion I had with a communication aid manufacturer, I was warned that what I say this afternoon might be taken as "gospel" because of my affiliation with the Trace Center. I don't know whether that's true or not, but one thing this same gentleman said did cause me to temper some of the more emphatically biased statements I was prepared to make. He said that many practitioners of his acquaintance in the field of augmentative communcations feel paralyzed in their attempts to prescribe an aid because something bigger and better is always just around the corner. Anyone who has purchased a microcomputer knows the painful truth of that statement. Indeed, something "bigger and cheaper" usually is announced, if not appearing on the shelves of your local computer store, the minute you get your computer home. However, that should not be a reason to delay a decision indefinitely. We have to weight the value of acquiring a device which is "better" in some way against the value of having a device which may not be optimal but is at least functional today. Especially in the case of applying a device with a young child, or a young person in the educational system, delay and resulting missed opportunities can mean irretrievable loss. So, I must preface my statements by saying that the critiques I am going to offer should not convince anyone to delay a decision on acquiring an aid system. Peoples' immediate needs are important and deserve to be met now, not when it is easier to make a decision, because in the forseeable future it is not going to be any easier to make a decision.

We all appreciate the dilemma, however. It reminds me of an incident that occurred to me recently. I wonder how many of you may have had a similar experience. A friend and I were driving home, I was at the wheel and he was giving directions. Well, my friend has CP and his speech is quite difficult to understand. It sometimes takes several passes and then some guesswork. At any rate, he's navigating and I'm driving - not the best of all possible situations, but probably better than the reverse, given his incoordination and my poor navigational skills. At any rate, I was having a hard time understanding what he was saying at one point and we became lost. Or so I thought. I had to pull off the road so I could concentrate on what he was saying and figure out where we had gone wrong. By this time my friend was laughing hysterically which made him all the harder to understand. The point at which he had begun emphatically trying to communicate a few minutes before, was the point at which I had decided we must be lost, since my friend was flailing away at me. When we got it all straightened out I found that he was trying to tell me we were right on track, not lost, going in the right direction even though I had taken a wrong turn a few blocks back. Right. Thanks, Bill, for the encouragement.

So, my point to you is that communicative delay can be as dangerous as making a wrong turn, or choosing a device which will be improved upon or made obsolete in the future. One of the emerging design criteria among manufacturers and rehabilitation engineers in this field is modularity,

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allowing hardware to be upgraded as improvements become available. This should ease decision-making for the consumer. Sometimes, I know, we also feel that we have only one shot, and we have to make this financial investment that is not refundable or replenishable. This is another feature of decision-making on aid systems that often works against us. But, we'll be getting into these issues later in our discussion.

For now, let's define some terms. We will be talking here about conversation, control and computer access aids. What we are trying to convey with that big mouthful of words is the idea that "communication aids" as we have known them now need to serve a number of functions beyond face-to-face conversation. Here are the three function areas we have identified:

1. Under the heading of "conversation" we include face-to-face conversation, defined as interaction in real time, and also telecommunication needs, defined as real-time message sending and receiving over distance.
2. Under "control" we include the operation of environmental devices, as simple as battery-operated toys and electrical outlets, or as complex and sophisticated as environmental control units and robots.
3. Under "computer access" we include writing (or word processing) and the ability to use standard and specially-designed software.

I had mentioned modularity as an emerging design criteria for manufacturers and rehabilitation engineers earlier. Another emerging design criteria that can be seen reflected in most of the commercially-available aids is the provision of these three functions. In fact, one aid system currently on the drawing boards at Trace has been named "TRINE" to reflect that three part functionality. I guess you can think of it as the holy trinity if that helps you to remember it. Not all popular aids provide these three functions, as we will see later.

Having defined the functions of an aid system, let us now look at the components. I will be talking about five major components of aid systems.

1. The physical interface is that part of the aid system that connects with the user's bodily control site. It may be a keyboard, touch panel, voice control, joystick, eye switch, electrode, head pointing device, mouthstick or any other method or device which is used to send information to the central unit. It is at this end of the system, hopefully, that you will find whatever physical customization is necessary for an individual user.
2. The selection technique refers to the method by which the signals from the physical interface are interpreted. Scanning, encoding, direct selection and combinations of these selection techniques are all used. The selection technique is not necessarily dependent on the aid or the physical interface used. As with modularity and trifunctionality, the trend in recent years by most manufacturers and rehabilitation engineers has been to design aid systems which are capable of supporting various selection techniques. Some aid systems are, however, designed to support a particular selection technique; this is not necessarily unwise, though it may limit the marketability of a particular device. The Tetrascan and Scanwriter, for example, support only scanning, but they do so

in virtuoso fashion.

3. Acceleration techniques are used to speed up message rate or to increase content derived from whatever means of information transfer is available. Rate of information transfer remains the single largest stumbling block to the effective use of aid systems. Given the fact that the vast majority of aid system users are not capable of ten-fingered typing, and that not even ten-fingered typists can keep up with a usual conversational rate of around 200 words per minute, acceleration techniques must be used to enhance communication rates. Encoding, which I mentioned before as a selection technique, can also be used as an acceleration technique. When 3 digits are used to represent a phoneme, encoding is being used as a selection technique. At the same time, and on the same aid system, three different digits might be programmed to output an entire word. In this case encoding is used for both selection and acceleration. The Phonic Ear Vois 140 is an example of this technique.

Another common example of an acceleration technique would be the use of menu items used to indicate selections. Blissymbols represent an acceleration technique, although they are of course much more than that alone, they use a symbol to represent an idea. Recent examples of acceleration techniques include the Minspeak system from Prentke Romich Company, the Loleco program from Adaptive Communication Systems, and Speedkey, coming soon (we hope) from the Trace Center. In all of these systems, one or two selections, be they pictures, letters or numbers are expanded by the aid system to represent a word, phrase or sentence to the message receiver. Other examples of acceleration techniques include anticipatory scanning and word and letter frequency layout schemes commonly in use on many aid systems.

4. Output forms or actuators you can think of as simply the end result of this stream of information from the aid system user to the message receiver. Displays, whether LCD, LED, CRT, VDT or any of the other dynamic type acronyms you can come up with are in this category. So are printed output, voice output or output in the form of action by any other device such as a turtle or an environmental unit.
5. Finally, to complete this path of information transfer, we must talk about the underlying processes involved in the formulation, coordination, and execution of communication and control activities, including language, motor control systems, perceptual motor coordination, cognitive processes, etc. This is the area that we know least about. As engineers, clinicians, teachers and educational technologists, we have only begun to design tools which will allow us to study these processes in our clients. And we frequently make fallacious assumptions about the unknown capabilities of memory, language learning and social skills required by these marvelous high technology devices we are busily creating. If, as one author has named it, augmentative communication is the "dark continent" of rehabilitation, surely the underlying processes involved in the application

of these aids is the "dark continent" of augmentative communication.

Thus far, I have described the functions and the components of a complete high technology aid system. Let us now look at some of the commercially available systems on the market and begin to name names. My purpose here is not to provide a blow-by-blow comparison of the individual systems I will mention, but rather to see how well the entire field measures up to providing the user with necessary features, and to stimulate discussion of the ways in which these necessary features might be better provided.

I will mention 4 different aids in my discussion. Each of these have been presented at this conference and they are on exhibit. Each represents a slightly different approach to the problems they address. Once again, let me stress that my intent is not to evaluate the performance, quality or technical specifications of the individual aids, but rather to point out features and similarities in the field as a whole. I do not have, and I do not believe anyone has, the data to demonstrate that one of these aids is any better than another. Some lack certain features. Some would be more appropriate for a given individual than another. There are literally dozens of aids on the market that may be very similar or even superior to the aid systems I will mention. I will mention these four aid systems which are well known and are each prominent for varying reasons. I will mention the Express III, the Tetrascan and Scanwriter, the Phonic ear Handivoice, and SpeechPac. The commonality that these aid systems share is portability, voice output and fairly heavy marketing in this field. Beyond that the similarities end. Let's take a look at how well the three function areas are served by these and all other currently available aid systems.

Communication

In the first area, communication, let's look at a particular output form - voice. How good is it? How intelligible is it? How useful or necessary? Certainly, it seems to be the hottest development in augmentative communication in the last few years. John Eulenberg spoke for a lot of people when he said that if radar ranges and coke machines can talk, so should communication aids be able to help people talk. So far so good. I think we can all see the advantages to providing a natural-sounding, artificial voice to a person who lacks the motor control to produce speech. However, (SLIDE) do current communication aids actually talk? We know that they make sounds which the message retriever can learn to recognize to varying degrees. However, it must be said that the currently available synthetic speech in these aids is far from 100% intelligible to the untrained ear. In fact, if I were to hazard a guess, and, believe me, I know that this is hazardous, I would have to say that my experience with four of the five aids I've mentioned would lead me to guess a ratio of less than 50% intelligibility on unique messages to the untrained listener. Several points must be remembered in this discussion:

1. Speech synthesis technology is still improving dramatically, and some existing voice-output aids will be upgradeable as the improvements continue.
2. Voice output, even if largely unintelligible to untrained listeners, may serve an important function for the user in establishing control over his environment, gaining attention, or conferring status upon the user. Voice output has been shown to provide a strong reinforcer and motivational tool as feedback to pre-schoolers

in language-learning tasks (Meyers, 1983).

3. In some cases, those receivers in the user's immediate environment will become expert listeners, and the intelligibility ratio will rise; it has been demonstrated that many listeners can with relative ease and rapidity, acclimate to a synthetic speech "accent."

On the other hand, questions must be raised about the functionality of synthetic speech which is less than 50% intelligible. Intelligibility is extremely subjective; much of what we glean from everyday conversations is derived from context: positional indicators, emphasis cues, inflection, listener's expectations. This makes intelligibility difficult to isolate and study. How well will a child's peers be able to understand or accept his synthetic speech? Studies in this area are only beginning, and our observational experience is limited, but it is time to open up discussion of these issues.

If voice output is seen as a necessary and desirable feature of the aid system sought, what limiting factors should be taken into account? For one thing, an additional output form is absolutely necessary when using voice output. In noisy environments current synthetic speech systems do not function well, because of both low volume and increased discrimination difficulties. In some cases volume can be increased through the use of an external amplifier, but this does not solve the increased noise ratio problem. In some systems, the voice output draws enough power from the aid to necessitate dependence on another output form for use when the charge is low or depleted. As with any electronic aid use, non-electronic backup systems such as a pointing board, cards or at the very least, visible "yes-no" signalling descriptions written on a prominently displayed card should be considered.

Yet another factor to consider in thinking about the application of synthetic speech is how flexible the device user can be. One aid-user with whom I frequently converse by reading his written display had a very hard time making a synthesizer perform for him because it was extremely intolerant of spelling errors and other extraneous or missing characters. Unlike a human de-coding the written display, a synthesizer is unable to automatically filter out typos, thus introducing an additional noise element into the information transfer equation. And many aid users have educational deficits which include poor spelling and memory skills.

In their current manifestation, I believe that speech synthesizers can best be thought of as perhaps providing additional speech cues to the listener, as well as sound effects and signalling capabilities. They may also provide the user with an additional expressive outlet. In constructing exceptional pronounciations the user can exercise creativity and express his own personality in a new audible way. This has undeniable value. However, I do not believe that the current aid user today is enabled to "talk" with all that term implies, by the mere addition of synthetic speech capability, and it does not serve anyone's interest to pretend that he is.

Just a footnote before I desert this controversial topic. I was recently told, by a person who shall remain nameless, that we at the Trace Center have had our appreciation of synthetic speech spoiled by listening to the DecTalk too much. Perhaps that's true. The DecTalk is larger, heavier and much more expensive than any of the speech synthesis technology I've been talking about so far. There can be no argument that it is also much more intelligible. It was not battery-operable, but we have adapted one unit for portable battery-operated application, mounted on a wheelchair. The price difference

between the DecTalk, which has 11 voices including several women's and child's voices, and the synthesizers I've been referring to in currently-existing aids, is about $4000.

I have a friend who was a singing teacher until he hit a high E a little too hard. Workman's compensation allowed him to purchase a voice output aid system while he underwent 7 weeks of voice rest. And among all of this man's observations about his vocal odyssey, one stood out among the others. He was fond of saying that he is grateful for the Volkswagen aid system the state of Missouri allowed him to purchase, but he reminds listeners that his former voice was a Cadillac. If you haven't heard the DecTalk I have a phone number you might be interested in trying. But only if you like Cadillacs.

The closest real time "talking" that I have personally heard from a commercial aid user came from a man who would be described as a "master tool user." Using phonemic input and digitalized speech output on the Phonic Ear Vois 140, I have observed an expert user holding an oral conversation in real time, at a slowed but functional rate of speaking. But phonemic input also has drawbacks. It cannot be directly transcribed to traditional orthography written communication. This expert user must audio tape any messages he needs to convey, as written output is not enabled by this method or device. Those already familiar with traditional orthography, spelling, would have to learn a new phonemic orthography. And, on this particular aid, text-to- speech and computer access capabilities are totally absent. Yet, for the single function provided, the Vois 140 would seem to fall into the category of a tool rather than a toy.

Telephone Use

The capabilities of synthetic speech for telephone communication are of great interest currently. At least one device has been created expressly for the purpose of telephone communication via synthetic speech. How effective is it currently? Again, the answer is unknown. Two things can be stated. Synthetic speech may actually be more intelligible when filtered through the telephone transmission bandwidth than when unfiltered. This somewhat peculiar artifact is due in part to listener acceptance of a natural voice transmitted via telephone which is also missing some of the aural information present in face to face communication. This observation is unqualified: the only sure way to satisfy yourself as to its validity is to try out the device in question over the phone and form your own highly subjective, biased opinion as I have. There really aren't enough of these devices in use yet to collect information on their functioning in the real world.

Secondly, user techniques need to be developed to assist in successfully applying synthetic speech to telecommunication needs. An answering tape which alerts the caller to the system being used and includes some brief tips on how to proceed has been used by one client I know of. Unfortunately, in this case user and caller intolerance of the signal-to-noise ratio in the aid system's synthesized messages resulted in a failure to use the system at all. It should be noted that the user in this case had a temporary disability, and consequently, perhaps, a lessened motivation to make the system work.

For many people the telecommunication function is critical to support independent living. Telephone usage is absolutely necessary for safety and health reasons. As consultants and clinicians, we should be likely to notice this need since we are frequently on the other end of the line trying to retrieve what is often a very information-poor message. Why have we not responded to this need? All of the expensive, limited-function devices on the market

will not supplant effective training to telephone communication techniques. Here are some simple strategies I have found in use by some augmentative "masters."

1. The person using a combination of natural speech and augmented communication should check the accuracy of the transmission frequently. One person I talk to does this by ending most sentences with "Right?" and waits for an affirmative before going on. If he gets a "No, sorry" his next utterance is preceded by "Okay" before he launches a repeat or a variation of the utterance which was not properly received.
2. Similarly, the message receiver should echo the transmission if there is any doubt about its content and offer an opportunity to correct it.
3. The message-sender should know when to give up pronouncing a word or phrase and spell it. The receiver can assist by asking for spellings if necessary.
4. One individual I know and communicate with by phone on a weekly basis uses an interpreter very effectively. His phone calls are always welcome because the first thing he does is to set the topic and the length of the conversation, as well as the expected action he is seeking in calling me. All of our phone conver sations should be so succinct! This individual has learned to dispense with statements about our health or the weather as well. He respects my time and the limitations of this particular mode of communication. When we need to talk privately or in greater detail, he calls my computer via modem and puts a lengthy treatise in my electronic mailbox. Or, we speak interactively via computer. At his end he can type about 16 words per minute using a mouthstick and straight spelling. On my end I can talk with someone in my office, read the paper, watch TV or file my nails; use that time. If it's the end of the day I can lean back and catch my breath. I have found this particular mode of long distance communication very relaxing, and am in all honesty much more willing to converse with this person at length even though he is using a slow augmented rate.

Somehow we need to incorporate these techniques of augmentative master communicators into the uses we make of electronic telecommunication devices. I am not at all sure that we are currently developing these aids in tandem with the master tool users who can provide this information.

Written Display

No discussion of voice output would be complete without taking a look at the visual displays accompanying voice output devices. I will state categorically that at this stage of the game, with voice output being what it is, an alternate written visual display is necessary to back up the voice output. Four of five aids mentioned have both dynamic LCD displays and built-in printers. However, it is extremely difficult to read the LCD displays in actual interaction. Consider the Autocom. For all of its shortcomings, one thing it did have was a clear, readable LED display. It even has a separate, modular, tiltable display unit which could be mounted to face the message retriever. How important is face-to-face communication, eye contact, facial expression, gestural cues? (turn back on audience) Well, maybe it's

not really important. Maybe face-to-board communication is just as good. Before I have the manufacturers jumping up out of their seats let me say that I appreciate the technical problems involved with providing the kind of clear, readable, modular display I'm talking about. But we should admit that while the LCD displays have allowed us to solve one technical problem in the power supply area, their use actually represents decreased functionality in another area to the aid user. Can we perhaps find a technical solution to this problem? One which is affordable? I would submit that we can't until the importance of the visual display is first recognized. And what about these printers? How are they actually used?

The printer on the Epson HX-20, which is the core of both the SpeechPac and Words Plus systems, is very noisy. It requires additional communication time to first send text to the printer, wait for it to print, advance the paper, and then rip and read. I have been told by an Epson user that this noise inhibits his use of the printer, although with encouragement he has been willing to make greater use of it. The printed output is invaluable for private conversation and messages that take a long time to compose.

Control and Computer Access

I will touch only briefly on these areas. They are covered in more detail in several of the presentations at this conference.

As mentioned before, tri-functionality has become almost a standard in the augmentative field in the past several years. Computer access and remote operation of devices in the users' environment are seen as absolutely necessary functions for multiply-handicapped people having cognitive impairment as well as for those who are cognitively intact. Software development for those with mental retardation, learning disabilities, brain injury and language disorders has progressed markedly over the past several years.

What, then, is the rationale for an aid design which does not provide either of these functions? Would it be possible to implement the apparently successful selection and acceleration techniques of the Phonic Ear aids in a configuration which allows computer access and control functions?

All of the other aids thus far mentioned - The Express, the Tetrascan, and SpeechPac - not only provide, but readily facilitate computer access and control functions.

The Tetrascan has a built-in keyboard emulating interface; the other aids mentioned, with exception of the Phonic Ear aids, interface easily with available emulating interfaces which are now available. Thus, transparent access, defined as the ability to use standard software without necessitating standard keyboard input, is now readily available. This represents real progress from first specialized software and then intermediate, low-cost solutions such as the adaptive firmware card.

Another development that is currently available in this function area is the provision of a wireless link, whether infra-red or some other technology, to provide remote control of a standard computer or environmental devices from the aid system. This has been implemented on the Tetrascan and the Express III.

The major problems in this area lie not in the design or functionality of the existing devices, but in availability and cost. Environmental control units may cost as much as all the other components of the aid system combined, including the computer. Keyboard emulators must be specifically designed for the particular computer they are to be used with; thus, the person wishing to use an aid system with a computer in a vocational setting will be frustrated unless the computer he wishes to access happens to be an Apple II+, IIe, or IBM-PC. And with new computers appearing constantly,

this is not a trivial consideration. Being tied to a particular computer limits mobility.

Summary

Now that we have discussed some of the problems in all three of the function areas defined, I would like to desert my tirade about the shortcomings of currently available solutions and direct your attention to some questions and problems which transcend the responsibilities of manufacturers.

I must thank Larry Weiss of Zygo for alerting me to this publication of the Office of Technology Assessment. It's called Health Technology Case Study 26: Assistive Devices for Severe Speech Impairments. This is an excellent publication and I highly recommend it to you.

In this document, the situation of aids provision is likened to the situation of orphan drugs - Those needed by too few patients to make their development and manufacture by pharmeceutical firms sufficiently profitable. I would like to suggest that we are involved in an orphan field - one in which insufficient resources across the entire spectrum limit the availability of effective solution strategies.

Of course it is unfair to blame manufacturers for this situation. A vicious circle where lack of knowledge begets errors, and where errors beget frustration with service delivery systems exists. Manufacturers should not be responsible for the funding of devices, or for the research on interfaces and acceleration techniques. Yet, in the absence of any other activity in this area, they are often cast in this role. Because there is virtually no funding available for research or training of clinicians or users, or for adequate information dissemination, we seem to spend an inordinate amount of energy chasing elusive solutions. I would like to quote briefly from this OTA document:

> "There is an old axiom in medicine that when there are many different treatments for the same disorder the likelihood is that none of them works very well. From the perspective of the severely physically disabled nonvocal person, the same principle applies in finding a payment mechanism for the assistive communication device that will meet his needs: The many potential sources for funding disguise the reality that reimbursement can be very difficult and sometimes impossible to obtain. Because no single agency in government or the private sector is specifically authorized to assist this population, all tend to say it is not their responsibility and try to shift that responsibility elsewhere." (Office of Technology Assessment, 1983)

One last thought I would like to offer for your consideration this afternoon. We have heard a great deal about the communication revolution, the explosion, the marvels that can be wrought by the decreasing price of technology. How many of the problems I have identified can be solved by decreasing hardware costs alone? We need to set goals - what is it we can accomplish and want to accomplish? Isn't it time that we begin to decry the orphans status of this field and discover not simple solutions, but real ones?

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